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CHRONIC IMPLANTATION OF ELECTROMAGNETIC FLOW PROBES ON MAJOR ABDOMINAL VESSELS IN THE DOG[1,2,3]

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SUMMARY • *As part of a study to determine the effect of dietary fat on splanchnic and peripheral blood flow patterns, it was necessary to chronically implant electromagnetic flow probes on major abdominal vessels. The surgical technic employed in the procedure was described.*

Investigations have been undertaken to study means of increasing the caloric density of prepared foods by increasing the fat level or by the use of synthetic high-energy compounds. Since high-fat foods have a slower rate of passage through the digestive tract (2, 3) and splanchnic circulation is increased up to 40% after ingestion of a meal (1, 4), a fatty meal causes a prolonged increase in splanchnic circulation. Experimentation was initiated to determine whether splanchnic flow increases at the expense of flow available to the working muscle masses, thereby possibly impairing muscle function. In order to perform the study, electromagnetic flow probes were placed on the coeliac and cranial mesenteric arteries and the abdominal aorta of dogs.

PREPARATION

Five young male beagle dogs weighing 11–14 kg were used for the experiment. Food was withheld for 24 hr and water for 12 hr prior to surgery. The probes[6] were washed in soap and water and soaked in absolute alcohol for 12 hr before implantation. On the day of surgery, hair over the right cephalic vein was clipped, the skin was swabbed with 70% ethyl alcohol, and a flexible Rochester-type catheter (Jelco® I. V. Catheter Placement Unit, Jelco Laboratories, Raritan, N. J.) was introduced into the vein. Light anesthesia was induced with 2½% sodium thiopental (Pentothal®, Abbott Laboratories, Chicago, Ill.) given to effect via the catheter, and was maintained throughout the preoperative preparation. A Magill-type endotracheal catheter was used for tracheal intubation. With the dog in right lateral recumbency, an area extending from directly over the last rib 10 cm caudally, and from the dorsal to ventral midlines was clipped and vacuumed. The skin and adjacent hair were scrubbed thoroughly with hexachlorophene soap (pHisoHex®, Winthrop Laboratories, N. Y.) and rinsed with 70% ethyl alcohol. An area 8 cm square on the dorsal midline, centered over the caudal borders of the scapulae, was similarly prepared. The dog was then moved to the surgical table, secured in right lateral recumbency, and anesthesia was maintained with methoxyflurane (Metofane®, Pitman-Moore Co., Indianapolis, Ind.) using a closed-circle inhalation machine (Heidbrink® Veterinary Ane-

[1] Work performed in the Subsistence Evaluation Laboratory, Nutrition Division, Food Laboratory, U. S. Army Natick Laboratories, Natick, Massachusetts.
[2] This work was performed while the author (then Captain, USAF, VC) was stationed at the U. S. Army Natick Laboratories. Present address: Fission Product Inhalation Laboratories, Lovelace Foundation for Medical Education and Research, 5200 Gibson Boulevard, S.E., Albuquerque, New Mexico 87108.
[3] In conducting the research described in this report, the investigator adhered to the "Principles of Laboratory Animal Care" as established by the National Society for Medical Research.
[4] This paper reports research undertaken at the U. S. Army Natick (Mass.) Laboratories and has been assigned No. TP-708 in the series of papers approved for publication. The findings in this report are not to be construed as an official Department of the Army position.
[5] Accepted for publication April 20, 1970.
[6] Manufactured by Statham Medical Instruments, Inc., Oxnard, Calif.

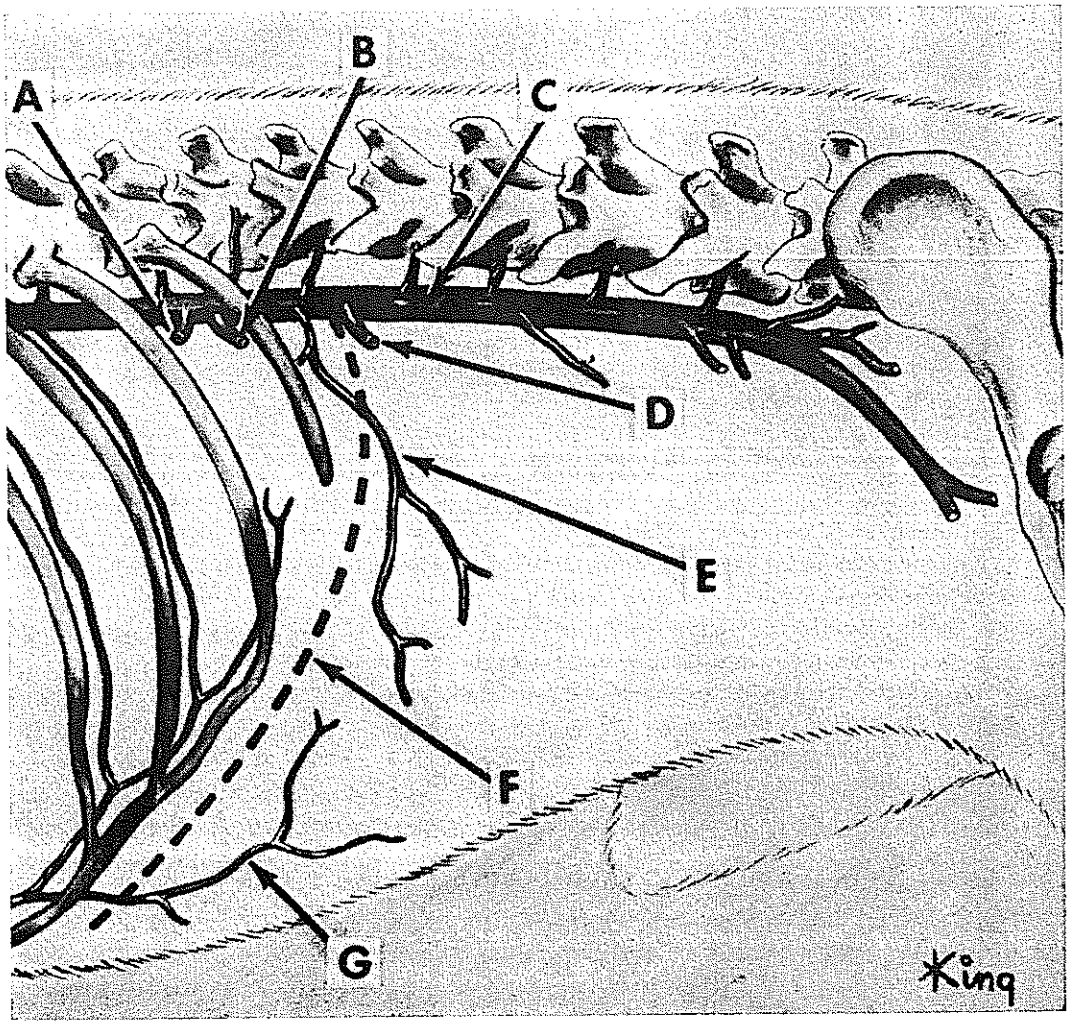

Fig. 1. *Superficial and deep arteries in operative field: A) coeliac artery, B) cranial mesenteric artery, C) aorta, D) left renal artery, E) phrenico-abdominal artery, F) incision line, G) cranial superficial epigastric artery.*

sthetic Machine, Ohio Chemical & Surgical Equipment Co., Madison, Wisc.). A continuous intravenous drip of normal saline was maintained throughout the operative procedure via the catheterized cephalic vein. Normal sterile technic was observed.

Operative Technique

An incision into the abdominal cavity was made 2 cm caudal and parallel to the last left rib and costal arch. The incision was extended from the lateral border of the lumbar muscles to 3-4 cm from the ventral midline. As each muscle layer was transected it was separated from adjacent layers 1 cm in either direction for ease of identification and apposition during closure. Pressure hemostasis was adequate for most hemorrhage, and 5-0 silk was used to ligate larger branches of the cranial superficial epigastric and phrenico-abdominal arteries (Fig. 1). Frazier retractors were used to spread the abdominal opening. The spleen was lifted from the abdominal cavity, positioned outside the ventral aspect of the incision, and wrapped in a saline-

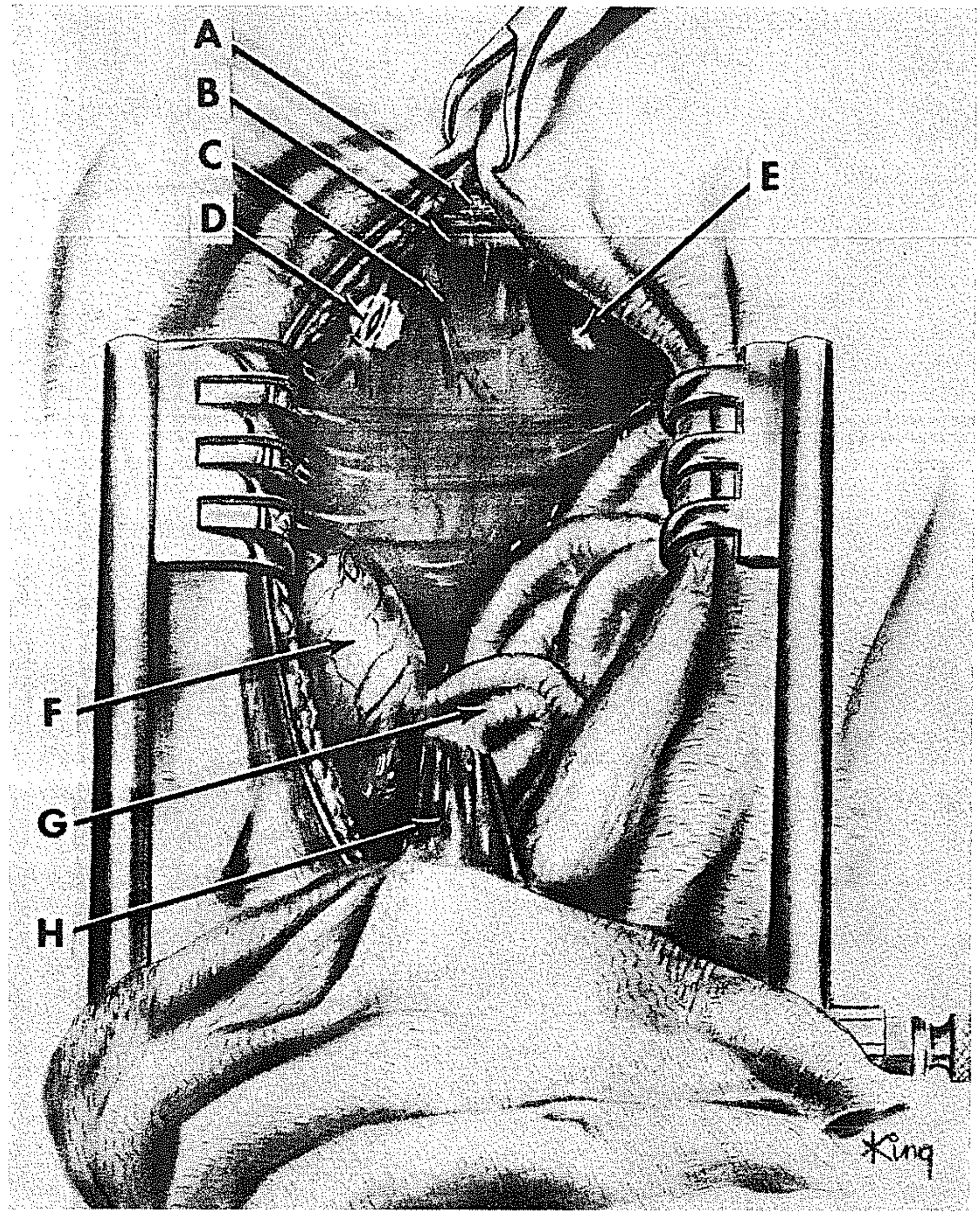

Fig. 2. *Operative approach to the coeliac and cranial mesenteric arteries: A) lumbar musculature, B) aorta, C) cranial mesenteric artery, D) coliac artery, E) left kidney, F) stomach, G) intestines, H) splenic attachment.*

soaked sterile towel. The spleen, muscles, and other exposed tissues were periodically moistened with sterile saline throughout the operation.

Retraction of the spleen caused the stomach and intestines to be deflected laterally and ventrally, and only slight packing with gauze sponges was necessary to isolate the

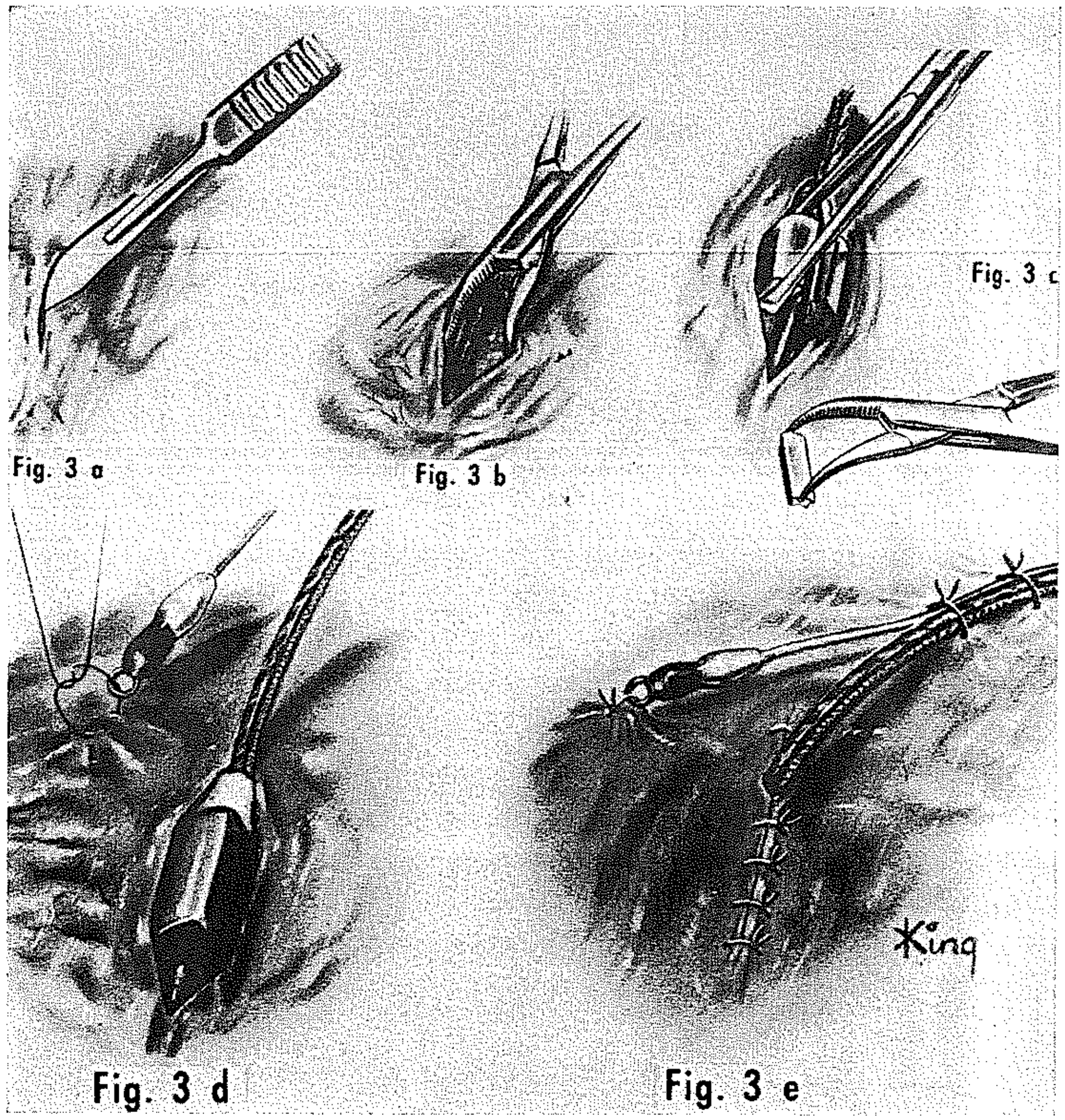

Fig. 3. *3a) Incision of the peritoneum over the coeliac artery; 3b) exposing the artery by blunt dissection; 3c) positioning the probe for key insertion; 3d) position of the probe and ground wire prior to suturing; 3e) implantation site after closure of the peritoneal incision, showing attachment of the wires to the peritoneal surface.*

surgical field. The left kidney lay beneath the dorsal angle of the incision, and cranial to it the peritoneal surface of the midline structures and common mesentery could be seen. The coeliac and cranial mesenteric arteries were enclosed within the common mesentery and were not readily visible, but by palpating the mesentery near its dorsal attachment pulsations were felt and the arteries thus located (Fig. 2).

A 1.5 cm incision was made in the peritoneum directly over the coeliac artery along its long axis, extending ventrally from the aortic origin of the artery (Fig. 3a). The artery was exposed by blunt dissection using Halstead mosquito forceps (Fig. 3b). Extreme caution was exercised to prevent rupture of the vessel or damage to the coeliac plexus which encircles the artery. When an area approximately 1.5 cm long was free from perivascular tissue, a snap-key, electromagnetic flow probe (Q series, Statham® Flo-Probe, Statham Medical Instruments Inc., Oxnard, Calif.) was placed on the vessel with the wires extending toward the dorsal midline. Allis tissue forceps were used to grasp and rotate the probe until the key slot was accessible (Fig. 3c). Lack of space around the probe precluded the normal method of snapping the key into place, so mosquito forceps were used to slip the key into the slot from one end. The key side of the probe was rotated medially, and the ground wire terminal was sutured to the peritoneal surface 2 cm dorsal to the probe head (Fig. 3d). At that time the probe was connected to the flowmeter, and the baseline adjusted for zero flow by temporary occlusion of the vessel distal to the probe head with Carmalt forceps. Once probe function and baseline was established, the same method was used to implant and test a probe of the same type on the cranial mesenteric artery. The peritoneum was sutured over each probe head with 3-0 chromic gut (Fig. 3e).

The aorta was approached by incising the peritoneum over the dorsolateral aspect of the left kidney at its attachment to the body wall, thus allowing the kidney to be deflected ventrally. Gauze sponges were used to retain the kidney and its adipose capsule in a ventral position, exposing the left renal artery and psoas muscles. The aorta, lying medial to the psoas muscles, was exposed by blunt dissection, and the portion caudal to the left renal artery, between the third and fourth lumbar arteries, was loosened from surrounding tissue. Again, caution was exercised not to damage the arteries, surrounding nervous tissue, or the posterior vena cava immediately to the right of the aorta. A hinged-cuff, thoracic probe (K series, Statham®) was placed around the aorta, checked for proper fit, and snapped shut (Fig. 4). The ground terminal was sutured to the surface of the psoas muscle near the probe head and the baseline established by temporary occlusion

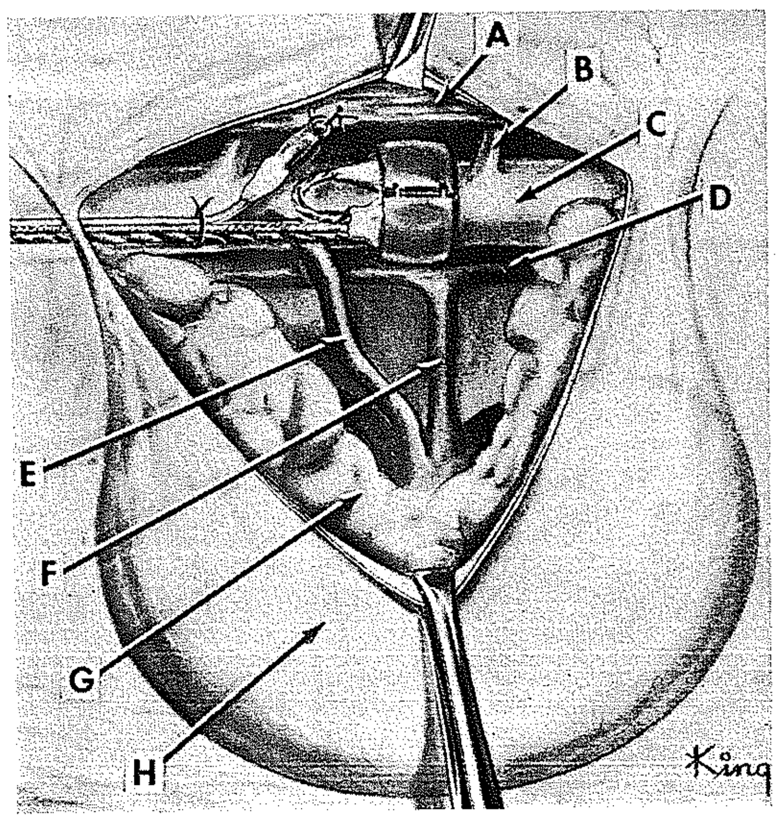

Fig. 4. *Anatomic placement of aortic probe: A) psoas muscle, B) fourth lumbar artery, C) aorta, D) posterior vena cava, E) left renal artery, F) left renal vein, G) adipose capsule, H) peritoneal attachment.*

as with the other probes. The kidney was returned to its original position, and a simple continuous suture of 3-0 chromic gut was used to close the peritoneum, allowing the wires to exit at the cranial angle of the incision.

The 6 wires, 2 from each probe, were then sutured together with gut and fastened to the body wall just inside the dorsal angle of the incision. Each wire was adjusted to conform to the contour of the mesentery and body wall and was held in place with gut sutures where necessary. The spleen was then returned to the abdomen. The peritoneal and muscle layers of the incision were closed with 2-0 chromic gut, allowing the wires to pass out of the abdomen at the dorsal angle. The skin was sutured with Supramid® (size: medium, Jensen Salsbery), leaving 3 cm of the incision open for the emerging wires at the dorsal angle. A simple interrupted pattern was used in suturing all layers.

A 2.5 cm incision was made through the skin on the dorsal midline, extending caudally from the caudal borders of the scapulae. Nine-inch straight Doyen intestinal forceps were introduced into the incision and forced through the subcutaneous tissue in a ventrolateral direction until the tip appeared in the open portion of the abdominal incision. The probe connectors were then grasped by the forceps and drawn through the subcutaneous tunnel one at a time until all wires lay under the skin, emerging from the dorsal incision. At that point, the hub piece of a teflon hub and washer assembly (Cardiovascular Instrument Corp., Wakefield, Mass.) was placed around the wires. The assembly had been

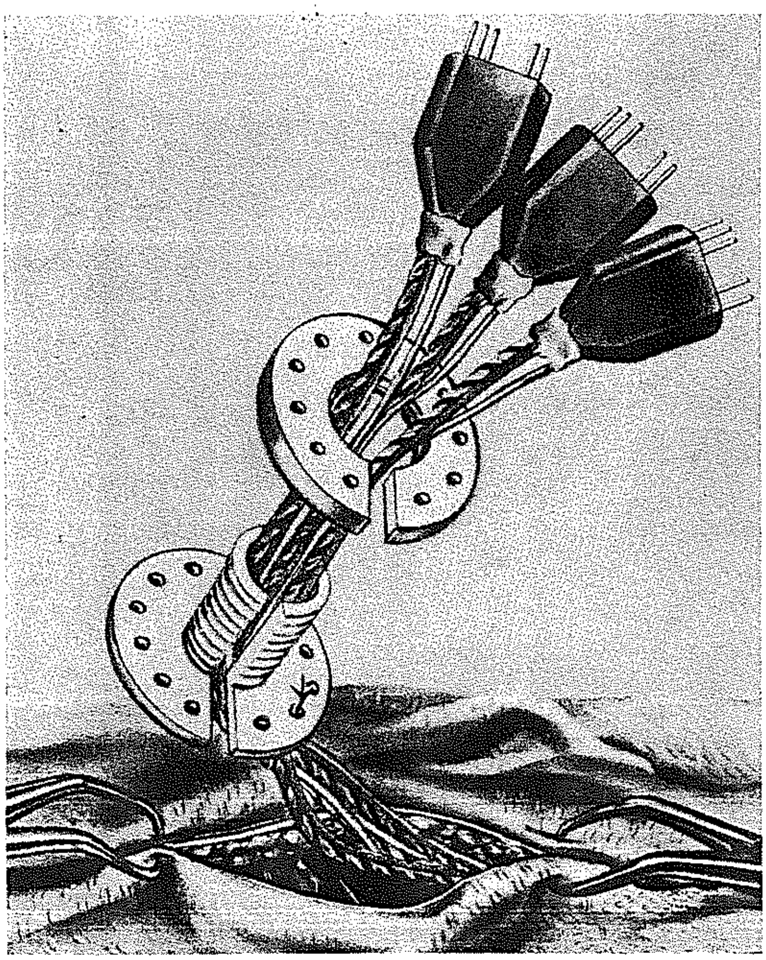

Fig. 5. *Connector wires emerging through skin of back with hub and washer assembly.*

made to specification and had a lumen diameter of 6 mm which snugly accommodated the 6 wires. The wires were adjusted so the connectors extended 4 cm from the hub and were then sutured to the hub flange with several loops of 1-0 braided silk (Fig. 5). The hub was then placed in the subcutaneous space of the incision and fastened to the underlying tissue with 4 simple sutures of 1-0 silk placed at regular intervals around the flange. The skin incision was closed with simple sutures of Supramid®, allowing the hub neck and enclosed wires to extend through the incision to the surface. The washer was screwed onto the hub until it touched the skin, and 1 anchoring suture of Supramid® was placed through the washer and skin to prevent its turning off. Slack in the wires was removed by forming them into a loop in the open subcutaneous area of the abdominal incision and suturing them in place under the skin with 2-0 chromic gut. Closure of the incision was then completed.

Postoperative Care

Following surgery, all skin incisions were painted with tincture of iodine, and the cranial half of the thorax was bandaged to protect the dorsal incision area. The bandage was changed daily for 4 days, and thereafter the dog wore a harness which had a foam-lined hard cover that protected the probe wires and kept the area clean. An ointment containing bacitracin and neomycin was applied to the area where the wires emerged from the hub lumen daily for 4 days postoperatively. The area was washed daily with water and hexachlorophene soap throughout the experimental procedures.

Each dog received 400,000 units of procaine penicillin G and 0.5 g dihydrostreptomycin sulfate on the day of surgery and three-quarters of that dose on each of the following 4 days. Three dogs had subcutaneous fluid accumulation in the abdominal incision area for 1–3 days postoperatively. The fluid was drained daily with an 18-ga hypodermic needle. Skin sutures were removed on the seventh day after surgery. In all cases, the dogs were alert, moderately active, and ate on the day after probe implantation.

Discussion

The clipped areas on the skin surface were kept as small as was consistent with sterile technic due to the relatively heavy harness that was to be worn continuously starting only a few days after surgery. The hair served as padding and prevented skin chafing. Extreme caution was exercised throughout the procedure to insure a close fit of the sterile drapes to the edges of the incisions.

Since the operative procedure was lengthy, averaging approximately 3 hr, it was essential that exposed tissues be repeatedly moistened with saline. This was especially true of the kidney, the surface of which is easily damaged when dry.

The simple interrupted suture pattern used throughout most of the procedure is time consuming but was chosen for its inherent strength and safety due to the size and position of the incisions. Silk was used for positioning of the hub and washer assembly, since there is much movement in the area and permanent sutures are needed. Gut was used in retaining the probe wires to facilitate their later removal.

The hub and washer assembly had been designed to accommodate the 6 wires very snugly so there would be little communication between the body surface and the subcutaneous space. Connective tissue adhesions formed quickly around the hub base, and there was rarely any fluid exudation and no apparent infection at the site. In all cases, probes were surgically removed and the dogs were salvaged after a period of 5–6 weeks. By that time, connective tissue growth around the probe heads precluded further use of the dogs for similar probe placements, although their general health and body functions appeared unaffected.

Probes with a lumen diameter of 3–5 mm were required for the coeliac and mesenteric arteries, with the coeliac usually requiring a probe 1 mm larger than the mesenteric. Probes with 7–10 mm lumens were used on the aorta.

This technic yielded a successful chronic preparation which was maintained from 4–8 weeks before probe removal. It appeared that an even greater number of probes could have been used simultaneously is desired. The lateral, paracostal approach to the abdomen and the suprarenal approach to the aorta represent an alternative to the classic mid-line approach and may be useful in many abdominal preparations.

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